Intelligent Energy Control For Distributed Generators Using Multi-Agent System With ANN

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Abstract: **Multi agent system has been used to provide intelligent energy control and management in grids because of their benefits of extensibility, autonomy, reduced maintenance etc. The multi agent system constituting the smart grid and agents such as user agent, control agent, database agent and distributed energy resources. In this project the wind power generator connected with local load, the solar power connected with local load and energy control center controlled by fuzzy logic controller. In fuzzy logic controller we can use multiple input and output sources. Fuzzy logic is a convenient way to map an input space to output source. The proposed is implemented with Artificial Neural Network based to achieve better performance compared to conventional controllers and simulated the proposed project in MATLAB/SIMULINK software.**

Key words: **Distributed Energy Resources (DER); Distributed Generators (DG); Fuzzy Logic Controller (FLC); Artificial Neural Network (ANN);**

I. INTRODUCTION

An economical and efficient electric power system is a vital component of a nation's economy. The demand for electrical energy is ever increasing. Today over 21% of the total electrical energy generated in India is lost in transmission (4% – 6%) and distribution (15% – 18%). It is possible to bring down the distribution losses with the help of newer technologies in the electrical power sector, which will enable better monitoring and control. Distribution losses can be reduced, if the DER is connected near the load end. The smooth operation of a power system requires a control architecture that consists of hardware and software protocols for exchanging system status and control signals. This is accomplished by supervisory control and data acquisition systems [1], [7]. A smart grid is an intelligent grid that integrates advanced sensing technologies, controls and communicates with current electricity grid at transmission and distribution levels [1], [3].

Later, multi agent system is utilized as an application development tool that enables system integrators to create sophisticated supervisory and control applications for a variety of technological domains, mainly in the power industry [1], [4]. Multi-agent system offers various advantages over the SCADA system by the implementation of an intelligent grid [4], [8]. Modeling the power distribution management process focusing on outage management has been elaborated by Hammer [8]. Planning for distributed generation and securing SCADA system is described by Roger [8]. Intelligent Distributed Autonomous Power System is given in [5]. Interaction between distributed generation and the distribution network operation aspect is explained in [6]. Proposal of a local DC distribution network with distributed energy resources is given in [8]. Esmaili and Das elaborated a novel Power conversion system for distributed energy resources [1]. SCADA system provides communication architecture capable of controlling and maintaining power system hardware using certain signaling protocols. The Energy Control Center (ECC) has traditionally been the decision center for the power generation and transmission of interconnected system. It consists of Energy Management (EMS) software. The Energy Control Center functions for power system is mentioned [2]. Most utility companies purchase their EMS from one or more EMS vendors. These EMS vendors are companies that specialize in design, development, installation and maintenance of EMS within ECCs [9]. The main objective of this work is to develop and implement an intelligent ECC using multi-agent system that would enable real-time management of DER with smart grid.

II. DESCRIPTION OF ENERGY CONTROL CENTER AND MULTI AGENT SYSTEM

A multi-agent system which stands a few steps ahead of a SCADA system is used to manage the grid. The component of multi-agent system and their functionality are given in [1] and [7]. The block diagram is shown in Fig. 1. The server has a wireless connection with the client as shown in

Fig.1. This is done using socket programming, which forms a part of the application program. This communication enables a DER agent (from the client side) to manage the power that is to be distributed to the necessary loads. DER agent, solar and wind power generator are connected to ECC through the Internet. This data is stored in database agent in ECC. The control action is taken by FLC present in ECC, based on the data from DER.

The multi agent system operations are shown in fig.2. User agent, control agent and DER agent communicate with the data base agent. This data base is sent to the server through a remote terminal unit like a conventional SCADA system RTUs are special purpose computers which contain Analog to Digital Computers (ADC) and Digital to Analog Converters (DAC) .These converters are digital inputs are used to get the system status and outputs are used to control.

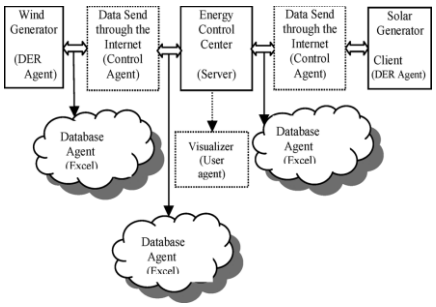

Fig.1. Block diagram of ECC.

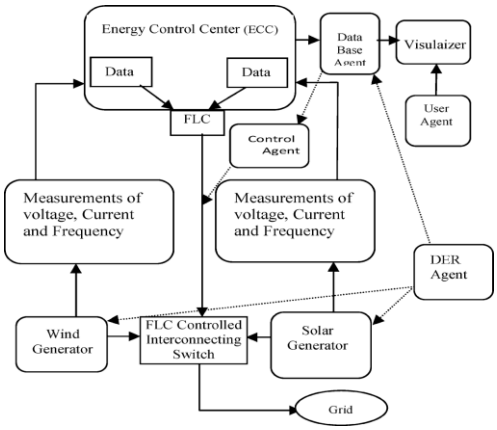

Fig. 2. Operation of multi agent system

They can be connected to any hardware device to acquire the analog data from any other device. The visualizer receives copies of all messages exchanged with in the multi agent system and is responsible for displaying these messages to the users with user agents. A multi agent system controls and monitors the DER power delivery. It is used for monitoring the voltage, load management, energy management, automated meter reading and substation control. The block diagram of the multi-agent system simulation model is given in Fig.3.Wind power generation consists of a wind mill, induction generator connected to the grid through circuit breaker and the load. Solar power generation consists of solar panel, inverter, transformer connected to the load and circuit breaker. The interconnection of wind power, solar power and grid forms the power system smart grid with DER. The voltage measured in wind power generator and solar power generator is sent to ECC through the Internet. The FLC present in ECC activates the circuit breaker according to the voltage requirement. The addition/removal of solar panels to the grid is controlled by FLC. If solar panel is removed from the grid, it will be connected to charge the battery. Since FLC is used for the control, it can be extended to control circuit breaker (CB-1) and circuit breaker (CB-2), as given in Fig. 3, depending up on the availability of DERs.

III. INTRODUCTION TO ARTIFICIAL NEURAL NETWORKS

Artificial Neural Networks (ANN) are a branch of the field known as "Artificial Intelligence" (AI) which may also consists of Fuzzy Logic (FL) and Genetic Algorithms (GA). ANN are based on the basic model of the human brain with capability of generalization and learning. The purpose of this simulation to the simple model of human neural cell is to acquire the intelligent features of these cells.

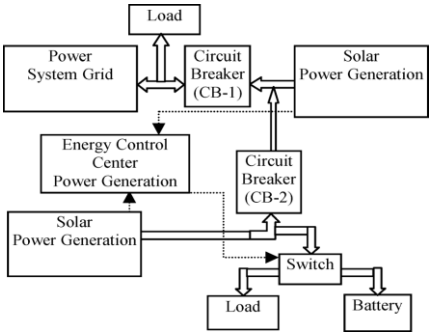

Fig.3 .Block diagram of power system interconnected with wind and solar power generation scheme.

The term "Artificial" means that neural nets are implemented in computer programs that are able to handle the large number of necessary calculations during the learning process.

ANN have gain a lot of interest over the last few years as a powerful technique to solve many real world problems. Compared to conventional programming, they own the capability of solving problems that do not have algorithmic solution and are therefore found suitable to tackle problems that people are good to solve such as pattern recognition. They have been therefore successfully applied in various application areas such as finance, medicine (clinical diagnosis and image analysis), engineering and physics. Moreover, ANN have been introduced in solving a lot of

problems related to prediction, classification, control and identification. This is due to their high ability to learn from experience in order to improve their performance and to adapt themselves to changes in the environment in addition to their ability to deal with incomplete information or noisy data and can be very effective especially in situations where it is not possible to define the rules or steps that lead to the solution of a problem.

The basic computing element in the biological system is the neuron which receives electrochemical signals from different sources and generates electric impulses to be transmitted to other neurons. The human nervous system consists of about 10^{10} to 10^{12} neurons which are capable of storing numerous bits of information. Each neural cell works like a simple processor and only the massive interaction between all cells and their parallel processing makes the brain's abilities possible. About 10% of the neurons are input and output whereas the remaining are interconnected with other neurons performing storage of information and transformation of the signals being propagated through the network is shown in fig 4. A neuron is composed of a nucleus, a cell body, numerous dendrites links which provide input connections from other neurons through synapses and an axon trunk which carries the output action to other neurons through synapses and terminal links. The connections between the neurons are adaptive, what means that the connection structure is changing dynamically.

Similar to the biological neural cell, the unit of structure of ANN is the neuron which consists basically of a summer and an activation function as shown in Fig. 5.

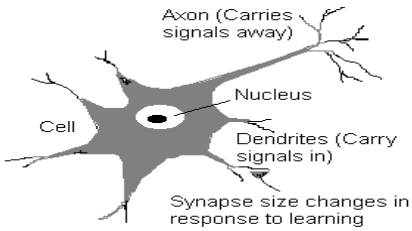

Fig.4. Artificial Neural Network Model

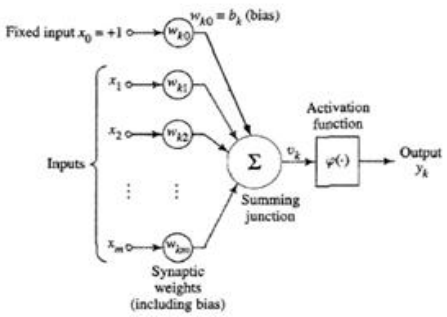

Fig.5. Structure of a ANN controller

IV. MATLAB/SIMULATION RESULTS

Simulation results of this paper are as shown in below Figs 6 to 13.

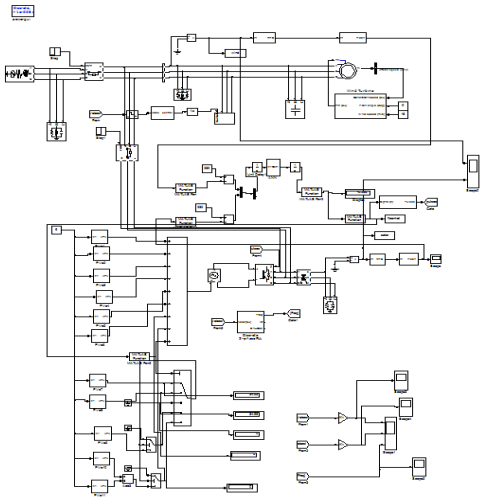

Fig.6.Simulation diagram of power system interconnected with wind and solar power generation scheme with ANN

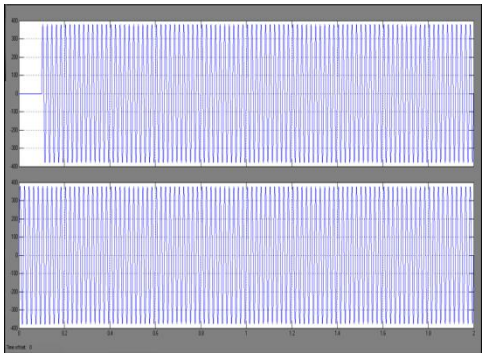

Fig.7.Voltage waveform of wind and solar power – circuit breaker (CB-1) closed after 0.1 s and circuit breaker (CB-2) closed after 0.3 s to interconnect solar power to wind.

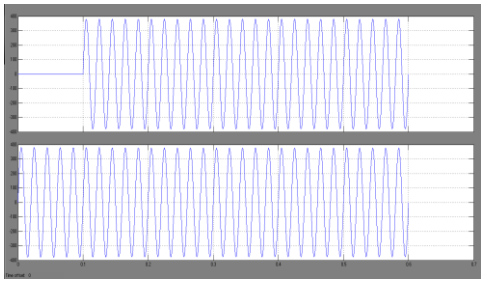

Fig.8.Voltage waveform of wind and solar power – circuit breaker (CB-1) closed after 0.1 s and circuit breaker (CB-2) closed after 0.3 s to interconnect solar power to wind observed up to 0.6 sec.

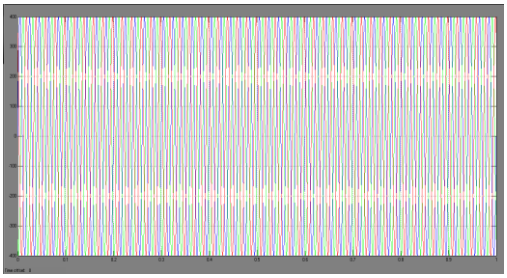

Fig.9. Simulation waveform of Three-phase voltage

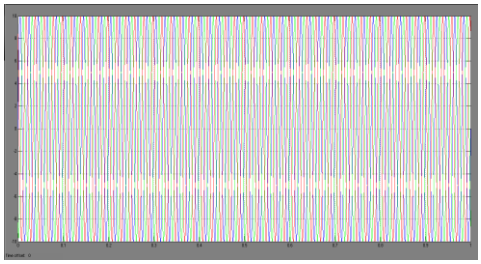

Fig.10. Simulation waveform of Three-phase current

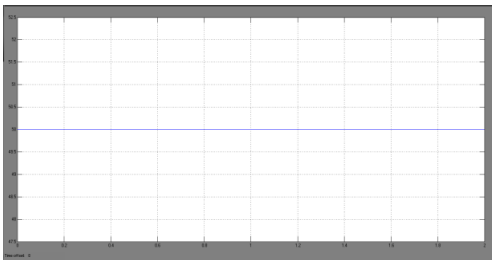

Fig.11. Simulation of system frequency of the power system

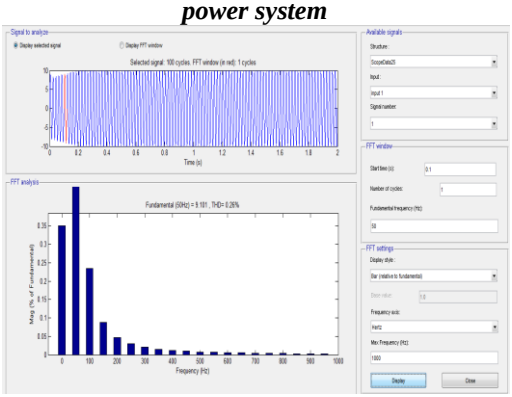

Fig.12. Simulated THD calculation for FLC Controller.

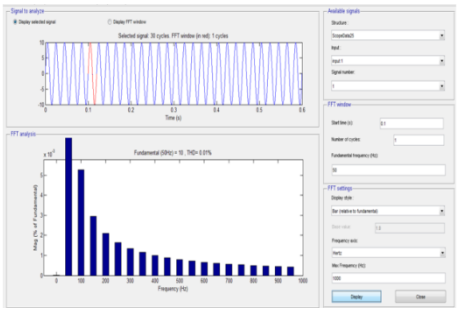

Fig.13. Simulated THD calculation for ANN Controller.

TABLE I: THD Comparison

	Method	
	FLC	ANN
THD Value(%)	0.26%	0.01%

V. CONCLUSION

In this paper, a hybrid technique is proposed to control the load voltage of solar panel and wind power generator. The hybrid technique consists of a combination of FLC with ANN controller. The hybrid model is simulated using MATLAB/SIMULINK software. In this proposed method we are using ANN controller we can reduce the total harmonic distortion value (0.26% to 0.01%) and it is compared with the Fuzzy Logic Controller.

VI. REFERENCES

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